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History of Trephining.

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CRANIUM—DEPRESSED BONE—COMPRE-
SSION OF THE BRAIN—A CASE—STRA-
BISMUS—RECOVERY.

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HISTORY OF TREPHINING.

FRACTURE OF THE INNER TABLE OF THE CRANIUM.—
DEPRESSED BONE.—COMPRESSION OF THE BRAIN.—
HISTORY OF TREPHINING.—A CASE.—STRABISMUS.—
RECOVERY.

BY WM. D. FOSTER, M. D., Kansas City, Mo.

"No injury to the head is too slight to be despised, or too grave to be despaired of."—HIPPOCRATES.

The treatment of fractures of the skull has been justly held to involve many difficulties. From its exposed position, the head is liable to frequent and varied accidents; from the importance of its contents—the brain, injuries to this part present an interesting study to the surgeon, possessing, usually, marked elements of danger to the individual. The surgeon, brought face to face with the grave and often complicated problems thus unfolded must determine and act with celerity. He has little time to reflect, and none to consult authorities. He must be prepared for the emergency. With the purpose, therefore, of elucidating some of the latest views and soundest principles which prevail relative to the treatment of these injuries, we will interrogate somewhat in detail, the surgical records of the past as well as those of the most distinguished authors of the present, and inquire into the results of the operation of trephining.

The student is bewildered at the outset by the diversity of notions encountered. Were the beginner, the tyro, to govern his operative steps by the voice of authority, to whose dictum would he give ear? In surgery it is not always wise to be governed by the preponderence of testimony. This inquiry is not only interesting from a surgical stand-



point, but will develop, incidentally, the multifarious and conflicting doctrines which have gained prominence in different countries, and at widely remote periods. The practical fact in regard to the operation of trephining is: When is it clearly warrantable?

OPERATION OF TREPHINING.

The circumstances which require this operation are:

1. Compound fracture with depression of bone, with or without symptoms of compression.
2. Simple fracture with depression and symptoms of compression, after a fair trial of ordinary means.
3. Punctured fractures, no matter what may be the condition of the brain.
4. Extravasation of blood between the skull and dura mater, or in the arachnoid sac on the cerebral hemispheres.
5. The existence of pus in the same situations.
6. Foreign bodies.
7. Epilepsy and other secondary effects.*

Trephining the cranium should be regarded as an operation always fraught with danger,† and only to be performed from absolute necessity.‡

The following general rules should guide us in deciding the question:§

1. In diffused injuries to the cranium and its contents all operative interference is unjustifiable.
2. In simple fractures, with or without depression, operative interference is only called for when marked and persistent symptoms of local compression of the brain exist.
3. In compound comminuted fractures, with or without brain symptoms, the depressed bones should be elevated and the fragments removed, with the object of taking away known sources of irritation to the membranes—a common cause of encephalitis.
4. In all local cases of traumatism of the cranium, of fractures or other injury, followed by clear

* Gross, *System of Surgery*, Vol. 2, p. 174. Edition 1877.

† Erichsen, *Science of Art of Surgery*, 1860.

‡ Ranney, *Practical Medical Anatomy*, 1882.

§ Bryant, *Practice of Surgery*, 1872.

clinical evidence of local inflammation of the bone, and persistent symptoms of brain irritation or sub-osteal suppuration, the operation should be undertaken.

There are certain suggestions* which are safe to follow in cases where the propriety of surgical relief is called in question:

1. If the injury be situated on the motor area of the cortex, the presence of anaesthesia in combination with motor hemiplegia, is a contraindication to attempts at relief.

2. If the sensory region of the cortex be involved and paralysis or convulsive movements occur, an operation is contraindicated.

3. The occurrence of paralysis on the same side as that upon which the injury was received, is always a contraindication to any surgical procedure at the seat of injury, since it indicates some lesion of the opposite side, probably dependent upon transmitted force (*contre coup*).

4. The completeness of the paralysis may be often taken as a guide to the amount of injury done to the cerebrum; if the paralysis be very profound, the chance of success from the trephining is extremely small.

5. The appearance of paralysis of any of the special nerves of the cranium and vomiting may be regarded as contraindications to surgical interference.

6. If the region over the fissure of Rolando be subjected to apparent injury, and the symptoms of some of the special types of monoplegia appear, successful trephining may be reasonably expected.

The presence of anaesthesia would, however, still be a strong contraindication to such a step. It must be also remembered that the motor paralysis of whatever kind must be confined to the side of the body opposite to the seat of injury, if benefit is to be expected.

The foregoing rules and suggestions are deserving of the most pointed condemnation. They are neither theoretically plausible, nor clinically correct,

*Ranney, loc. sit.

and clearly calculated to mislead. A rigid adherence thereto would have deterred any surgeon from undertaking the operation reported further on; nay, gauged thereby, it would have been plainly unjustifiable. Further, were these propositions sound, the availability of the trephine would be at an end; for after a careful examination of the details of every well authenticated case of trephining to be found recorded in the annals of surgery—both civil and military—no single case falls entirely within their scope. Confronted with such advice, and acting thereon, the surgeon would let his patient with a broken head perish without attempting any operative step for his relief. Such refinements are, and have been always, the cause of great mischief, and are undoubtedly responsible for much of the bad surgery in all ages.

The trephine should not be applied to any of the following points: the frontal sinus, the anterior inferior angle of the parietal bone; the course of the longitudinal sinus, the occipital protuberance and the different sutures.*

The accomplished Sir Wm. Fergusson† assures us that “the trepan may be applied to any part of the side or upper portion of the cranium,” that he imagines the meningeal artery and sinuses may be avoided, giving directions how to proceed in case the former is wounded.

It is a nice point to determine whether in a given case the patient is laboring under concussion or compression, and to which condition the symptoms are due. In practice it is not uncommon to find these states co-exist. The appended differential epitome‡ will aid in reaching a just conclusion:

* Gross, *Ibid.* p. 175.

† *Practical Surgery*, p 471. Philadelphia, 1845.

‡ Gross, *Ibid.* p. 131-2.

CONCLUSION.

1. The symptoms are immediate, coming on instantly after the infliction of the injury.
2. The patient is able to answer questions with difficulty, and usually only in monosyllables, as yes or no.
3. Special sensation is still going on, the patient being able to hear, see, smell, taste and feel.
4. The respiration is feeble, imperfect and noiseless.
5. The pulse is weak, tremulous, intermittent and unnaturally frequent.
6. There is nausea and sometimes vomiting.
7. The bowels are relaxed, and there are sometimes involuntary evacuations.
8. The power of deglutition is impaired, but not abolished.
9. The bladder retains the power of expelling its contents; but sometimes, owing to the weakness of its sphincter, the water flows off involuntarily.
10. The voluntary muscles, although much weakened are still able to contract, there being no paralysis.
11. The pupils are usually contracted, and somewhat sensitive to light: the lids are open and movable.
12. In concussion the mind is in a state of abeyance: it is weak and confused, not abolished.

COMPRESSION.

1. An interval of a few minutes, or even of a quarter of an hour, sometimes elapses, especially if the compression is caused by extravasation of blood.
2. The power of speech is totally abolished; we may hollow in the patient's ear as loudly as possible, and yet there will be no response.
3. Special sensation is destroyed.
4. The respiration is slow; labored, stertorous, and performed with a peculiar sound.
5. The pulse is labored, soft, irregular, and unnaturally slow, often beating not more than fifty, fifty-five or sixty in a minute.
6. The stomach is quiet and insensible to ordinary impressions, even emetics.
7. The bowels are torpid, and are with difficulty excited by the action of purgatives.
8. Deglutition is impossible, and sometimes does not return for several days.
9. The bladder is paralyzed, and therefore incapable of relieving itself, the surgeon being obliged to use the catheter.
10. There is always paralysis on one side of the body, generally opposite to that of the compressing cause.
11. The pupils are widely dilated, and unaffected by light, the lids being closed and immovable.
12. In compression the patient is comatose, and the mind is temporarily abolished.

That the intricacy of diagnosis may be still more distinctly emphasized, it has been pertinently observed that "all these symptoms, conditions and causes have been made by many authors to appear very distinct in so far as language and printing are concerned, but in practice the difficulties in diagnosis are often so great that even the most experienced surgeon will occasionally be at fault; the co-existence of concussion and compression has been especially noticed by practical men, as also the impossibility of distinguishing which of these conditions is most urgent, and there are few indeed who can congratulate themselves on their invariable accuracy in the investigation of such cases.* The same eminent surgeon has further declared that in concussion, unless the injury be immediately fatal, nature seems in a manner to struggle against such an event, the patient recovers to a certain extent, and then perhaps inflammation may run its course, or possibly, the rally may be complete. Not so, however, in compression: this condition may not evince itself for several hours, days or weeks after the injury. Sometimes, in injury of the head, a person seems at first to suffer from concussion; in the course of a few minutes, half an hour or more, he, as it were, recovers from the shock, but for a brief time only. He gradually becomes insensible again, and all the symptoms of compression become more or less distinct. Such has been the history of some instances when the middle meningeal artery has been torn.

The treatment of depression must depend on circumstances. If the symptoms are evidently due to a depressed fracture of the cranium, recourse should at once be had to the operation of trephining. Where the compression results from effusion of blood within the membranes, the rule is laid down that if the symptoms are such as to show that the immediate dangers from compression are so great as to overbalance those arising from the meningitis which the puncture may induce, the membranes should be incised and the blood evacuated.† If a

* Fergusson, *loc. sit.*

† Smith, H. H., *Practice of Surgery*, p. 299, Ed. 1856.

person had received a blow on the temple, and if from the symptoms I suspected effusion of blood from the meningeal artery, I should not hesitate to perforate the cranium with a trephine, over the supposed collection; and in the event of compression coming on in the course of a number of days, and when suppuration might be suspected, the same method might be adopted.*

The treatment of depressed fractures, when combined with symptoms of compression, will consist in antiphlogistic resources and in the performance of the operation of trephining, with the view of elevating the depressed fragments and thus relieving the compression.†

In order to determine those parts of the brain which underlie definite points marked upon the exterior of the skull, the following engraving is suggestive. The line described by the base of the figure is known as the Alveolo—Condylloid Plane of Broca:‡

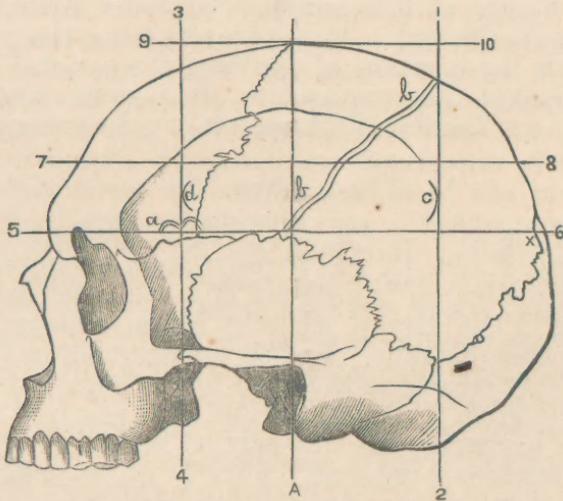


FIG. 1.

Outline of skull resting upon the Alveolo-Condylloid Plane of Broca (modified).

* Ferguson, *Ibid*, p. 469.

† Smith, *Ibid*, p. 336.

‡ Ranney, *Ibid*.

Vertical line A, or auriculo-bregmatic line 9-10, drawn parallel to the plane of Broca. Upon this line, at a distance of 45 m.m., posterior to the bregma or vertical line 1-2, will pass through the upper (inner) end of the fissure of Rolando, b, b, and through the posterior extremity of the thalamus opticus (c). A third vertical line 3-4, drawn at 30 m.m., forward of the bregma, will pass through the fold of the third frontal gyrus (a), and through the head of the nucleus caudatus (d). The horizontal line 7-8, at 45 m.m. below the bregma (scalp) indicates the upper limit of the central ganglia. The third horizontal line 5-6, passing through the external angular process of the frontal bone and the occipito-parietal junction, approximately indicates the course of the fissure of Sylvius, and serves for measurements. At 18 or 20 m.m. behind the external angular process on this line, is the speech center of Broca; 5 to 8 m.m. behind the intersection of 3-4 and 5-6, is the beginning of the fissure of Sylvius; and at 28 or 30 m.m. behind this intersection, is the lower end of the fissure of Rolando, b, b, placed a little too far back in the cut. At x (near 6), near the medium line, is the location of the occipito-parietal fissure.

Some of the perplexities of diagnosis and treatment are further illustrated in the following

CASE.

On the 24th of August, 1882, at four o'clock p.m., George F., aet. 15, was thrown from his horse. The animal became frightened and ran; the lad's foot hung in the stirrup, whereby he was dragged a considerable distance. In this predicament he was presumably struck on the head by the horse's shoe; the saddle girth finally broke and thus released the boy from his peril. He was carried home in a partially unconscious condition. Shortly afterwards vomiting set in and continued at intervals throughout the night.

Some hours subsequently he apparently fully recovered consciousness and complained bitterly of

pain in his head. The following day, Friday, he appeared conscious when aroused ; took some nourishment ; he was stupid and slept a good deal. Friday night he spent badly ; his head was hot ; he was restless and could only sleep a few minutes at a time ; frequently got up and changed from one bed to another ; he grew steadily and gradually worse, when, at five o'clock Saturday morning, August 26th—thirty-seven hours after the receipt of the injury—he had a convulsion, and became again profoundly unconscious. The convulsions recurred at intervals of thirty or forty minutes during the day. He took Belladonna, and had inhalations of Chloroform during the paroxysms. He became speedily quiet under the anæsthetic.

At four p. m., Saturday—forty-eight hours after the accident occurred—I was requested to see this patient in consultation with Dr. Peter Baker, who had the case in charge. At that time I learned the foregoing history and found the boy in the condition stated.

Examination revealed contusion and swelling over the left parietal region ; contusion and laceration of the skin on left side of the spinal column from the shoulder to the hip ; unconsciousness profound ; pulse slow and very full ; respiration retarded and partly stertorous. Fracture and depression of the left parietal bone, with compression of the brain diagnosed. Prognosis unfavorable. It is apparent that the vital powers are becoming rapidly exhausted ; that no *medicinal measures* are adequate to lift him out of his lethargy ; that the nerve centers cannot rally, unaided, from these accumulated burdens, thus excluding a trial of expectant treatment ; that unless the cerebral pressure be speedily relieved the patient will perish. In this emergency the question arises, What shall be done ? "The indication is the evident necessity for a fixed course of action."—(Galen.) What is that "fixed course of action ?" Undoubtedly to relieve the brain pressure by formal trephining. This alternative was suggested to the parents as offering the only hope of relief ; that the

result was doubtful and that the patient might succumb under the operation. Consent was unhesitatingly given, with the added injunction, to do the work thoroughly, omitting nothing which might conduce to their son's relief and to his ultimate recovery. Dr. Baker and myself were ably assisted and seconded in the various steps of the operation by Dr. Nofsinger (retired).

OPERATION.

A crucial incision thus -- , one and one-half inches long was made through the scalp over the center of the parietal bone. A considerable quantity of extravasated blood was turned out from under the scalp which was found to be extensively detached. The flaps were held aside with tenaculæ. The margins of the parietal at the sutures could be plainly felt by the probe under the scalp. The external surface of the bone was smooth, presenting no evidence of fracture in the outer table. Being guided by and acting upon general surgical principles, and keeping in mind that wise maxim, "Think you are operating on the thinnest skull ever seen, and thinner in one-half the circle than the other;";* the trephine was applied over the most depressed point on the bone, and a segment cautiously removed. Considerable haemorrhage occurred immediately the cranial cavity was penetrated. The blood was dark, being undoubtedly extravasated between the membranes and the bone. Examination of the button elucidated the whole situation; the fracture was found to be limited to the vitreous plate, the fissure being fortunately cut across by the trephine.



FIG. 2.

Appearance of inner surface of the button, showing line of fissure.

*Holden. Landmarks: Anatomical and Surgical. London, 1876.

The dura mater presented a dark red color, revealing inflammatory action ; no laceration of the membranes could be detected. The elevator was introduced and the depressed tables restored to their normal position. The boy stood the operation well and rallied promptly. He had no more spasms after the operation, and rested well during the night.

At three o'clock the following morning he roused up with returning consciousness, asked for something to eat, remarking that a "fellow couldn't get well if he did not eat," etc.—the first coherent utterance he had made in twenty-four hours. He speedily regained full consciousness, and made an uninterrupted and complete recovery. The scalp wound healed on October 31st.

During convalescence he had strabismus ; very marked in the left eye, a mere trace in the right one ; double vision ; objects appeared one on top of the other, or sideways, thus :

$\begin{matrix} h & \text{or thus,} & h \\ h & & h \end{matrix}$

This muscular asthenopia and the attendant errors of vision were speedily relieved by appropriate lenses —thirty-six inch convex for both eyes—and the administration of Gelsem.0 every three hours. The lenses and the remedy were prescribed by my friend, Dr. F. F. Casseday, oculist, of this city.

REMARKS.

The return of consciousness a short time after the accident and the long interval between that event and the supervention of unmistakable symptoms of compression, will recall the observation of Ferguson, already cited. Entire absence of paralysis of sphincters or other muscles will be noted.

From this history and the symptoms named it will be readily inferred that the diagnosis in this case was no easy affair ; that the proper course to pursue was at first in some doubt ; and indeed it may appear to the minds of some that the operation was undertaken upon insufficient ground. The result, however, demonstrated the wisdom of the proceeding.

RESULTS OF TREPHINING.

The operation in civil practice has been followed by varying results in the hands of different surgeons.* In the hospitals of Paris and Vienna the operation is nearly always fatal; in London, Dublin, Edinburgh, Glasgow, and other large cities of Great Britain, the mortality, although also very high, is much less; and in the United States the number of recoveries in proportion to the number of deaths, is as nearly as can be arrived at, as 1 to 4. Dr. Lente reports that of forty-five cases of fracture of the skull subjected to trephining, eleven were cured. The operation finds undoubtedly its greatest success in private practice. Of six cases coming under the writer's observation—five in his own practice—all made admirable and perfect recoveries. The sources of danger after operation are haemorrhage, erysipelas, encephalo-meningitis, pyæmia, fungus of the brain, profuse suppuration, hectic irritation, periostitis and caries.

Remarkable operations upon the bony vault are recorded by several different authors. Saviard trephined one person twenty times successfully; Martel and Le Gendre, in 1686, took away nearly the whole of both parietal bones, and yet the patient made an excellent recovery. Marechal applied the trephine successfully twelve times; Gooch thirteen times; Desportes twelve times; Schumaker relates a case where the operation was performed eleven times in less than a month, and with so little inconvenience to the patient that he seldom went to bed after it. Phillip, Count of Nassau, fractured his skull in several places by a fall from his horse: he was trephined twenty-seven times by Henry Chadborn, a surgeon of Neomagen, to whom, after his recovery, he gave a certificate as a proof of skill.

The most extensive use of the trephine in modern times is that recorded by Mr. Guthrie, to whom the details were furnished by Dr. Evans. The case was one involving both tables; twelve perforations were required to render the elevation of the depressed bone

*Gross. *Ibid.*

possible. The pressure was not then fully relieved until the dura mater was incised to evacuate the extravasated blood. The patient fully recovered. The membranes should not be incised if possible to avoid it, owing to the great danger of hæmorrhage and of encephalitis. Other cases of very extensive destruction of the cranial bones are recorded where the trephine was applied and the patients fully restored.

In military practice the results of trephining for fracture of the skull with depression are extremely disastrous. In the Schleswig-Holstein war, Stromeyer reports that of forty-one cases of gunshot fracture of the skull with depression, seven died and thirty-four recovered. Of the latter one was trephined—the only operation throughout that war, which issued favorably. This operation was most pointedly condemned by Stromeyer and the surgeons generally in that war. In the Crimean war the English surgeons operated, successfully, only four times, and then not on account of rifle ball wounds. In the French army Dr. Scrive asserted that the operation was mostly unsuccessful. Of twenty cases operated upon by Pirogoff and others only six recovered. In explanation of this melancholy result, it may be presumed that the operation was only a little more in fashion than with Stromeyer, and resorted to in cases of the gravest character alone ; and that then, in fact, the patients did not perish from the trephining, but from the primary wounds for the relief of which the operation was undertaken.*

In our late war the trephine was applied, it would appear, with much greater frequency, and with vastly more gratifying results. Of sixteen cases of operative interference after gun-shot contusions of the cranial bones, four only had a favorable termination, and these were examples of the secondary removal of exfoliated fragments, wherein nature was supplemented by art.† Dr. Otis ‡ records twenty cases of fracture of the *inner table*—nineteen of

*Gross. Ibid.

† Medical and Surgical History of the War. Pt. 1, Vol. 1, p. 126.

‡ Ibid, p. 150.

whom died. Trephining in four cases was unavailing. The operations were performed on general surgical principles. That they were unsuccessful only corroborates the opinion that has been so strongly impressed on the minds of surgeons of the present day that authentic examples of successful trephining for matter between the bone and dura mater are now very rarely cited.

The result of trephining for *all causes* in 220 cases, was : 95 recoveries, 124 deaths, 1 undetermined—being a mortality ratio of 56.6. To this list is added from records subsequently examined, nine cases—the histories of which are detailed : seven made more or less complete recoveries, and two died.

The distinguished Gross* states that fracture of the inner table of the cranium is “chiefly, if not exclusively, caused by gun-shot injury.” “The lesion is seldom discovered until after death, as it does not give rise to any marked, much less characteristic symptoms.” These assertions may be regarded as too comprehensive, as a considerable number of cases of this form of fracture are recorded by credible observers, which were not caused by gun-shot wounds, were correctly diagnosed, subjected to trephining and cured. That this fracture is most commonly caused as stated, and that the recognized cases are comparatively infrequent, would more nearly convey the exact truth. The writer of this paper has successfully trephined three cases of fracture of the inner table alone, under well-defined indications for the operation—none of which were caused by gun-shot injury.

HISTORY OF TREPHINING FOR FRACTURE OF THE INNER TABLE.

It has been asserted that this form of fracture was known to Hippocrates, Celsus, Paul of Aegina, Vidus Vidius, and other ancient writers, but the evidence is insufficient. Mr. Teevan † declares that Jacobus Berengarius was one of the earliest writers

* System of Surgery, Vol. 2, p. 152.

† The British and Foreign Med. Chir. Rev., Vol. 36, p. 189.

who was aware of this lesion. Ambroise Paré[‡] certainly records the first case of this fracture wherein he found, after death, that the inner table was depressed, the outer being uninjured. Subsequently cases are recorded, one by Garengœut[§] successfully trephined. Saucerotte,^{||} among others, quotes one case from Tulpus, 1716, which terminated fatally after trephining. Le Dran^{*} records an example of this lesion caused by a fall, unsuccessfully trephined. Pott[†] furnishes two cases, both of whom died, one being trephined. In one instance the fracture was produced by a fall, in the other it resulted from a blow on the head. Pott adds that these are the only instances he had met of fracture of the inner tables alone, but that he made no doubt that some of those "thought to have been destroyed by concussion, have sunk under this kind of mischief."

Bilgeur^{††} records the case of a colonel of grenadiers, wherein the inner plate of the frontal bone was fractured by a small bullet; the trephine was applied three times, and the patient fully recovered. Ravaton^{§§} adduces one case, the injury being caused by a ball, the patient perishing without operation.

Samuel Cooper^{|||} trephined a man after the battle of Waterloo for compression resulting from a shot wound on right parietal bone; the external table came away in the hollow of the trephine, leaving the internal table behind, which was fractured and driven into the brain. No sooner were the fragments taken out than the man instantly sat up in bed, looked around, and began talking with the utmost rationality. He got up and dressed himself the same day and never had a bad symptom afterwards. Baudens[¶] records one case not subjected to operation, the patient dying on the fourth day from encephalitis. Bernhard Beck^{**} relates three cases

[‡] *Oeuvres*, Edition 1658, T. X., p. 225.

[§] Garengœut, *Traité des Opérations de Chirurgie*, Paris, 1738.

^{||} Saucerotte, T. 4, p. 322.

^{*} Le Dran, *Obs de Chirurgie*, T. 1, Obs. 17.

[†] Pott, *Wounds and Contusions of the Head and Chir. Works*.

^{††} Bilgeur, J. U., *Chirurgische Wahrnehmungen*, Berlin, 1863, p. 30.

^{§§} *Pratique Moderne de la Chirurgie*, Paris, 1776, T. 1, p. 210

^{|||} *Surgical Dictionary*, Hennen, and Brodie Med. Chir. Trans.

[¶] *Clinique des Plaies d'Armes a Feu*, Paris, 1836, p. 80.

^{**} Beck. *Die Schusswunden*, 1850. *Langenbeck's Arch.*, 1862. *Kreischiurische Erfahrungen*, 1867.

—all fatal—in two of which the injury was caused by gunshot wounds, the other by a blow on the head from a beer glass; none of these were trephined.

Ochwadt* records the case of a soldier who was struck on the left parietal bone by a bullet; death from encephalitis resulted on the seventh day. No operation was attempted.

Guttenburg † relates the case of a Baden soldier, who at Rastadt—1861—received a blow from a musket lock over the right parietal protuberance. He was not trephined and died on the twenty-fourth day.

Guthrie ‡ adds two instances of this lesion, one died and one recovered.

La Motte supposes that fracture of the inner table alone might be ascertained by the peculiarity of the resonance of the skull on percussion, resembling the “cracked pot” sound, described in late years by auscultators of the chest, and cites an illustrative case. § Atthalen, of Besancon held the same view, adducing an interesting and illustrative case which happened in 1746; but in this instance there was a fissure in the external table also. Stromeyer || also attaches value to this mode of diagnosis. He cites two cases, resulting fatally, neither of whom were subjected to the trephine. His interesting remarks on this subject are quoted at length: “This kind of injury, of which only one case has come to my notice, might be observed oftener if we still used the trepan as Pott did, or if one could obtain a reliable diagnosis without opening the cranium. By means of percussing with a silver probe, I was enabled in one case, when there was only a barely perceptible fissure in the outer table, to diagnosticate the extent of the inner separation accurately, and after the decease from pyæmia, in this same case, many of the young surgeons had the opportunity of convincing themselves of the correctness of my diagnosis. Any

* Kriegs chirurgische Erfahrungen, Berlin, 1865.

† Guttenburg in Langenbeck's Archives, B. 4.

‡ Cuthrie, Commentaries, 1855.

§ La Motte, Observation de Chirurgie, T. 2, p. 303.

|| Stromeyer, Maximem.

one of them, who possessed a practiced ear, could discriminate the sounds when percussing the outer table at the point of the internal fracture, or at other points of the cranium. At the point of the internal fracture the pitch is somewhat higher. Lanfrancus and Ambrose Paré, I find, already knew of this diagnostic expedient. It is wonderful that the inner table can be fractured and driven inwards considerably, while it is impossible to detect the least injury on the outer table by means of a lens even, as is the case in my specimens. At the same time, these cases are not isolated. Partial fractures of bones by bending are analogous to them. The outer table evidently possesses a greater elasticity, and is more pliable than the inner. One can form a good idea of the elasticity of the skull, as Hyrtl says, by throwing a fresh cranium on the floor, when it will rebound. These inner separations remain generally undiscovered, which is in my opinion lucky for the patient, because thereby he escapes the danger of being trepanned. It is not assuming too much to suppose that these cases would generally result favorably if the patient was subjected sufficiently long to an antiphlogistic diet, because the danger incurred by these cases is evidently less than in others, where the access of air to the splintered part of the inner table takes place. For the older surgeons, who did not know the difference between subcutaneous wounds and those exposed to the atmosphere, the lesions in cases of head injuries formed a constant source of anxiety. They could not explain to themselves what would become of the secretion of the wound. We now know that when the atmosphere is excluded and proper care is taken the inflammatory exudation will become reduced to a minimum, sufficient only to permit the healing process; while it will never become so much as to require an external exit channel.

One need not revert fifteen years in surgical literature to be convinced that an unfounded dread of the impossibility of an exit for the secretions of the wound were then considered proper indications for

trepanning. The ample information which one of the most zealous advocates of trepanning, one who was an excellent surgeon as well as a truthful man, I mean Percival Pott, has given us in regard to the effects of trepanning, leaves no doubt as to the theory that the access of air increases suppuration. In most cases of simple contusions, in which he trephined on account of the formation of pus internally, very little pus was found at the first operation ; yet the symptoms were generally aggravated, and trepanning was resorted to a second or third time, and not until the secondary operations were great quantities of pus disclosed. Thus, as usual, one mistake brought about another, and one ill-advised use of the trephine rendered its repetition necessary. The main symptoms which seemed to demand trephining, for the majority of surgeons addicted to the trephine, consisted in the stupor or insensibility of the patient. It really requires no small degree of firmness of conviction of the danger of the trephine to see a patient, not only for days but weeks, in a state of greater or less stupor or insensibility without resorting to the operation, when sometimes complete consciousness is restored immediately by a successful elevation of the depressed bone, or the removal of extravasated blood. It is not enough to remind one that patients with typhus often remain for weeks in a still deeper stupor, and yet gradually resume the use of their mental faculties ; nor is it sufficient to recall the innumerable cases where trepanning, notwithstanding the apparent success of its purpose of elevating depressed bone, or removing extravasations, did not influence the restoration of consciousness, but where this was only gradually regained by means of an antiphlogistic treatment, one must have observed as often the successful cure of head injuries without trephining to be enabled to acquire such accuracy of observation, as nearly every physician possesses in regard to fever patients. Would not every one be called a miserable quack nowadays who would give a typhus patient musk, camphor or serpentina on account of stupor ? It will not be long be-

fore no favorable estimate will be had of any surgeon who will use the trepan on account of comatose conditions alone. The campaigns of 1849 and 1850 have, happily, given many young surgeons the opportunity to convince themselves with their own eyes, that one may look on a condition of semi-stupor for weeks without resorting to the trepan."

Pathological specimens of several other examples of fractures of the inner table only from external violence are referred to: one in the Dupuytren Museum, 29 A*. It is the calvarium of a young man trephined by Denonvilliers, in 1848, during the revolution in Paris; he died on the sixth day from encephalitis. Legonest† refers to a specimen of this fracture which he brought from the Crimea. Cowan‡ presented a specimen to the Museum at Fort Pitt. The subject was a soldier who died on the thirteenth day from a fracture of the inner table. No operation was made. Hewitt§ states that he observed three specimens of this form of fracture at St. George's Hospital.

Mr. Edwards|| presented a specimen to the Medico-Chirurgical Society of Edinburgh. The injury was produced by a blow from a cricket ball.

Demme¶ refers to one case, resulting from a musket ball, the preparation of which he has preserved; Friedburg ** reports one case in Virchow's Archives, the injury being caused by a fall; Bonetus†† mentions that Cortesius had a skull in which this fracture was illustrated.

References to further examples are to be found by Scultetus, 1662; by Soulier, of Montpelier, 1819; by Salmuthius, 1648; by Platner, 1758; by Balting; by Smethius; by Döring; by Kuhk. Still other examples are ascribed to Arcaeus, 1658; to Valleriola; and to Borel, 1676, but they do not appear to have been fair illustrations.

* Compendium de Chirurgie Practique.

† Legonest, Op. Cit.

‡ Williamson's Military Surgery; Holme's System of Surgery.

§ Medico-Chirurgical Transactions. 1853.

|| Edinburgh Medical Journal, 1862.

¶ Demme, Specielle Chirurgie, etc. Wurzburg, 1857.

** Virchow Archiv. 1861.

†† Bonetus. Geneva, 1700.

Guthrie ^{††} remarks that "the records of eighteen centuries have produced but little information on this most interesting subject. I have never, in the great number of broken heads I have had under my care on many different and grand occasions, actually known the inner table to be separated from the outer, without positive marks of an injury having been inflicted on the bone or pericranium, however slight that injury may have been. An operation should never, then, be performed under the expectation that such an accident may have happened unless it is apparently required by the urgency of the symptoms indicating compression or irritation of the brain, which cannot be relieved by other means."

The mechanism of this form of fracture has been misunderstood until a recent date. Gross appears to be among the earliest American surgeons who had a correct opinion on this point. "For centuries it had been taught that this form of fracture took place because of the great brittleness of the inner table." * Brodie [†] expresses the English view: "The greater elasticity of the outer table of the skull and the greater brittleness of the inner table, seems to afford the only reasonable solution of these phenomena." The French and German surgeons entertained a similar view. This was universally held and taught until 1865, when Teevan [‡] demonstrated that the cause of this fracture was not the brittleness of the vitreous plate, neither was it to be sought for in any of the reasons heretofore assigned; but that it occurred in obedience to a well-known physical law, viz.: that fracture always commences in the line of extension, not that of compression.



Fig. 1.

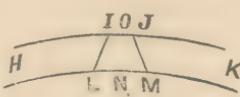


Fig. 2.

Fig. 3. Diagrams showing the mechanism of fracture of the inner table alone, of the skull.

^{††} Guthrie, *On Injuries of the Head, etc.*, p. 79.

^{*} Medical and Surgical History of the War, op. cit.

[†] Brodie, *Med. Chirurg. Trans.*, Vol. 14, p. 331.

[‡] Teevan, *Brit. and For. Med. Chir. Rev.*, October, 1865.

EXPLANATION OF THE DIAGRAMS.

Let A B, Fig. 1, be a section of the skull. Draw two vertical lines, C E and D F, parallel to one another. Now, if pressure be applied at G, temporary depression takes place, and the bone assumes the shape of H E, Fig. 2, and the lines C, E, D, F are no longer parallel to each other, but converge towards each other, at the upper surface I, L, J, M, so that the distance from I to J is less than that from C to D, but the distance from L to M is greater than that from E to F, signifying that the atoms of bone in the upper surface from I to J have been brought nearer to each other or compressed, whilst the atoms of bone in the lower surface from L to M have been extended or separated from each other; therefore if any fracture takes place, it is clear it must do so in the line of extension L M, and at that point in the line where the greatest extension is going on, which is at N, exactly opposite the spot O, where the pressure was applied.

PROOF.

Take a cane slightly bent, say A B, Fig. 1, and insert two pins or wires, C, E, D, F vertically and parallel to each other, the more the pins project at each surface the more manifest will be the result. Exert pressure at G till the cane is made flatter, H K. It will now be found that the wires are no longer parallel to each other, but converge along the upper surface so that the distance between them, from I to J, is less than that from C to D, but the distance from L to M is greater than that from E to F, showing clearly that the atoms along the line I J have been compressed and brought nearer to each other, whilst those along the line L M have been extended; consequently, if any fracture takes place it must be at N. If the pressure on the cane be continued till it breaks, it will be found it commences to break at N.

It is the force and not the direction of the violence that produces the fracture. "It is justly remarked that many cases of this form of injury terminate fa-

vorably and are never recognized, and, therefore that the diagnosis must generally be obscure until cleared up by the trephine or by autopsy." "It is evident that the treatment of this form of injury must be determined by those principles which guide us in treating scalp wounds, contusions of the cranial bones, concussion and compression of the brain. When symptoms of compression are urgent and persistent, the application of the trephine is undeniably justifiable."*

*Otis, *Medical and Surgical History of the War.*

